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ACOUSTIC WAVEFRONT DISTORTION AND COMPENSATION

Robert C. Waag

Department of Electrical Engineering
University of Rochester
Rochester, New York 14627

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Summary

Ocean propagation models were reviewed and a ray tracing model was selected for use in this research. An ray tracing program, TRIMAIN, was obtained and adapted to calculate time delay differences due to sound speed variation with depth in the ocean. An imaging algorithm was also obtained and adapted to include time delay distortion and to employ data covering a finite aperture with sparse sampling. Specially modified source code was documented and transferred to the Naval Research Laboratory. Maximum brightness, cross correlation, and triple correlation techniques for the compensation of wavefront distortion were studied and an overview with references was prepared. The propagation model and imaging algorithm were used with available measured scattering data to find image degradation produced by various combinations of sound speed profile, measurement aperture size, and spatial sampling rate. The results indicate little degradation occurs when the spatial aperture is limited by the reliable acoustic path and that image characteristics may still be recognized when the spatial sampling rate is significantly reduced.

Background

A general objective of research underway in underwater sound is to improve detection and classification of targets from their echoes since the consensus is that improvements in present capabilities are both desirable and possible. A basic phenomenon that can limit the capability of present systems to detect and classify targets is the wavefront distortion that acoustic pulses undergo as they propagate through the ocean from the source to the receiver aperture. Improved characterization of wavefront distortion caused by the ocean is needed to develop larger aperture sonar systems that allow increased resolution for classification of targets and increased signal-to-noise ratio under practical conditions.

Acoustic propagation in the ocean is a complicated process in which the shallowness of the ocean relative to propagation distances of interest plays an important role. During the course of propagation, wavefront distortion is caused by multiple paths, reflection from rough boundaries, and depth-dependent sound speed (1,2). Among these, the variation of sound speed with depth alters the path of acoustic waves by causing wavefronts to bend and may alone limit target detection and classification.

Imaging is one approach to detect and classify targets. The process of imaging can reveal a target through the presence of reflections or an equivalent source at a particular location (3). The structure of these can include information from which target classification can proceed. However, the presence of wavefront distortion can, even if detection is possible, change the appearance of the equivalent source and, thereby, prevent classification or result in misclassification.

Tasks

This research has been comprised of the following tasks.

1. Survey current ocean propagation models and make appropriate selections for implementation.

2. Acquire appropriate propagation programs and develop suitable software interfaces to target scattering models, signal convolution, image algorithm and suitable output.

3. Develop a suitable software interface to the NRL scattering database.

4. Investigate the extent of degradation due to propagation effects in a bistatic imaging sonar system.

5. Investigate the utility of image reconstruction techniques such as maximum brightness, cross correlation and triple correlation on the developed bistatic imaging sonar models.

6. Transfer computer codes to Naval Research Laboratory Physical Acoustics Branch.

References

1. R. J. Urich, "Sound Speed Propagation in the Sea", U. S. Government Printing Office, Washington DC 20402, Stock No. 008 051 0071-2 (1979).

2. I. Tolstoi and C. S. Clay *Ocean Acoustics*, American Institute of Physics, New York (1987).

3. P. B. Abraham and C. F. Gaumond, "Reflection Tomography", *Journal of the Acoustical Society of America* 82(4):1303-1314 (1987).